PATENT ABSTRACTS OF JAPAN

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(54) SHORT WAVELENGTH AND SHORT DURATION PULSE LIGHT SOURCE

(57)Abstract:

PURPOSE: To provide a small size and high power light source which can output a short wavelength and short duration pulse by outputting a sum frequency light as a short wavelength and short duration pulse light beam.
CONSTITUTION: The title pulse light source comprises a short pulse light source 1 and an energy injection light source 2. The light emission timings thereof are controlled to be synchronized by a timing period means 3. The short pulse beam from the short pulse light source 1 and the excited pulse beam from the energy injection light source 2 are coupled with a light coupling means 4 and are incident on a sum frequency light generating means 5. Letting the wavelength of the short pulse beam be λ s, and the wavelength of excited pulse beam be λ p, the wavelength λ o of the sum frequency light from the sum frequency light generating means 5 is expressed as follow: $1/\lambda o = 1/\lambda s + 1/\lambda p$. Only the sum frequency light of the wavelength $\lambda 0$ is branched by a light ranching means 6 and is then outputted to external circuits as an output pulse, that is, short wavelength and short pulse light beam.
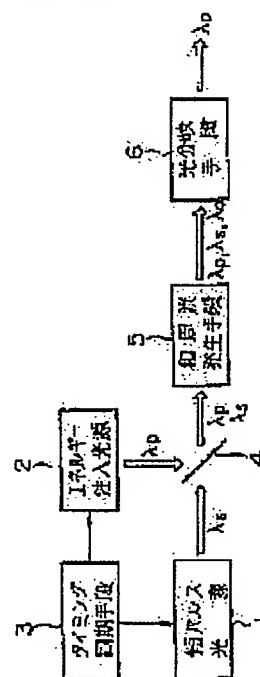
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CLAIMS

[Claim(s)]
[Claim 1] The 1st light source which generates excitation pulsed light, and the 2nd light source which generates the short pulsed light of short pulse width from said excitation pulsed light, The source of short wave merits-and-demerits pulsed light is equipped with a synchronous means to synchronize the luminescence timing of said 1st and 2nd light sources, and a sum frequency generation means to generate sum cycle light by carrying out incidence of said excitation pulsed light and said short pulsed light, and it was made to output said sum cycle light as short wave merits-and-demerits pulsed light.
[Claim 2] The source of short wave merits-and-demerits pulsed light according to claim 1 constituted so that said synchronous means may make the output of said sum cycle light max by adjusting one [at least] luminescence timing of said the 1st or 2nd light source.
[Claim 3] The source of short wave merits-and-demerits pulsed light according to claim 1 further equipped with the optical coupling means which is made to combine the output light of said 1st and 2nd light sources, and carries out incidence to said sum frequency generation means.
[Claim 4] The source of short wave merits-and-demerits pulsed light according to claim 1 further equipped with an optical branching means to separate and output only sum cycle light from the outgoing radiation light of said sum frequency generation means.
[Claim 5] The source of short wave merits-and-demerits pulsed light according to claim 2 constituted including a detection means by which said synchronous means receives a part of said excitation pulsed light by which incidence is carried out to said sum frequency generation means, and said short pulsed light so that one [at least] luminescence timing of said 1st and 2nd light sources may be adjusted based on the detection output of this detection means.
[Claim 6] The source of short wave merits-and-demerits pulsed light according to claim 2 constituted so that said synchronous means may adjust one [at least] luminescence timing of said 1st and 2nd light sources based on the detection output of this detection means including a detection means to receive a part of output light of said sum frequency generation means.
[Claim 7] The source of short wave merits-and-demerits pulsed light according to claim 1 constituted so that said synchronous means may make the output of said sum cycle light desired level including a means to set one [at least] luminescence timing of said the 1st or 2nd light source as adjustable.
[Claim 8] The source of short wave merits-and-demerits pulsed light according to claim 3 constituted so that said optical coupling means may make adjustable the spatial lap of said excitation pulsed light in said sum frequency generation means, and said short pulsed light.
[Claim 9] The source of short wave merits-and-demerits pulsed light according to claim 1 where said 1st light source consists of semiconductor laser excitation Q switch solid state laser.
[Claim 10] The source of short wave merits-and-demerits pulsed light according to claim 1 where said 2nd light source consists of semiconductor laser which generates the short pulsed light of a picosecond region.
[Claim 11] The source of short wave merits-and-demerits pulsed light according to claim 3 said whose optical coupling means is a dichroic mirror.
[Claim 12] The source of short wave merits-and-demerits pulsed light according to claim 4 said whose optical branching means is a dichroic mirror.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] Especially this invention relates to what uses sum cycle light for a detail about the source of short wave merits-and-demerits pulsed light.

[0002]

[Description of the Prior Art] That for which wavelength uses a higher harmonic by 500nm or less as a generating technique of the short wave merits-and-demerits pulsed light of a picosecond region, and the thing using sum cycle light are known. In order to generate a higher harmonic, the approach using large-sized laser equipments, such as dye laser, the approach (APL.54 (17) PP.1625-1627) of generating within a high power laser cavity, or the method of leading semiconductor laser (LD) light to the waveguide which consists of a nonlinear medium is used. Moreover, in order to generate sum cycle light, the approaches (Shingaku Giho, OQE 90-37, APL.54(9) PP.789-791, etc.) of setting a nonlinear device in a high power laser cavity, and mixing the output light of LD which carried out the high-speed modulation are used.

[0003]

[Problem(s) to be Solved by the Invention] However, with the technique by the harmonic generation, if the large-sized equipment like dye laser is needed and it miniaturizes using another side, waveguide, and LD in order to enlarge an output, it will become low-power output. Moreover, a nonlinear device is set to the interior of the resonator of LD excitation solid state laser, and according to the approach of modulating LD for excitation, quick switching cannot be performed by the life time of fluorescence of a laser medium, and it does not become short pulsed light.

[0004] On the other hand, like JP,1-214082,A, a nonlinear device is set to the interior of the resonator of LD excitation solid state laser of CW oscillation, and there is the approach of mixing the output light of LD which carried out the high-speed modulation to use sum cycle light. However, according to this, LD excitation solid state laser cannot make CW oscillation, therefore power density high, but conversion efficiency stops to about 1%. Moreover, pulse width is not set to about 5ns, either. Furthermore, since LD output is not so large when a modulation is applied to LD for excitation of LD excitation solid state laser, a nonlinear effect is small, and since the output light of LD can be condensed only to one side of a nonlinear medium or a laser medium, power density does not go up in both media, and high power is not obtained. Then, this inventions are small and high power, and aim at offering the source of short wave merits-and-demerits pulsed light which can output short wave merits-and-demerits pulsed light.

[0005]

[Means for Solving the Problem] The 1st light source which the source of short wave merits-and-demerits pulsed light in connection with this invention makes generate excitation pulsed light, The 2nd light source which generates the short pulsed light of short pulse width from this excitation pulsed light, It has a synchronous means to synchronize the luminescence timing of the 1st and 2nd light sources, and a sum frequency generation means to generate sum cycle light by carrying out incidence of excitation pulsed light and the short pulsed light, and is characterized by making it output sum cycle light as short wave merits-and-demerits pulsed light.

[0006]

[Function] According to the configuration of this invention, excitation pulsed light and short

pulsed light synchronize, incidence is carried out to a sum frequency generation means, and sum cycle light is generated by this. Here, the wavelength of sum cycle light fully turns into short wavelength corresponding to the wavelength of excitation pulsed light and short pulsed light, and the pulse-width becomes short enough according to the pulse width of short pulsed light. Moreover, if the timing of excitation pulsed light and short pulsed light is in agreement, the output of sum cycle light will serve as max, and an output is possible for adjustable by shifting timing.

[0007]

[Example] Hereafter, the example of this invention is explained to a detail with reference to an accompanying drawing.

[0008] Drawing 1 is the block diagram showing the basic configuration of the source of short wave merits-and-demerits pulsed light concerning this invention. This equipment has two sources of pulsed light of the source 1 of short pulsed light, and the energy impregnation light source 2, and that luminescence timing is controlled to synchronize with the timing synchronous means 3. It is combined by the optical coupling means 4, and incidence of the short pulsed light from the source 1 of short pulsed light and the excitation pulsed light from the energy impregnation light source 2 is carried out to the sum frequency generation means 5.

[0009] It is lambdaP about the wavelength of lambdaS and excitation pulsed light in the wavelength of short pulsed light here. If it carries out, it is wavelength lambdaO of the sum cycle light from the sum frequency generation means 5. 1/lambda O = 1/lambdaS+1/lambdaP It becomes. This wavelength lambdaO Only sum cycle light is taken out by the optical branching means 6, and is outputted outside as an output pulse, i.e., short wave merits-and-demerits pulsed light. In addition, the power of this short wave merits-and-demerits pulsed light is the power PS of short pulsed light. And power PP of excitation pulsed light It is proportional.

[0010] Drawing 2 shows the concrete example of the above-mentioned configuration. If it contrasts with drawing 1 , the source 1 of short pulsed light consists of the high power short pulse LD light sources 10, the energy impregnation light source 2 consists of LD excitation Q switch YLF laser light sources 20, and the timing synchronous means 3 consists of timing synchronizing signal generating circuits 30 so that clearly. Moreover, the optical coupling means 4 consists of a total reflection mirror 41 and a dichroic mirror 42, the sum frequency generation means 5 consists of nonlinear devices 50, such as BBO (beta-BaB 2O4) and KTP (KTiOPO4), and the optical branching means 6 consists of spectroscopes 60. In addition, L1 and L2 It is a condenser lens.

[0011] With such a configuration, the wavelength of excitation pulsed light is lambdaP =1047nm, for example, if wavelength of short pulsed light is set to lambdaS =900nm, the wavelength of short wave merits-and-demerits pulsed light will be set to lambdaO =484nm. And if the output of the LD excitation Q switch YLF laser light source 20 is set to 10microJ, for example and conversion efficiency of 10W and a nonlinear device 50 is made into 4 - 5% for the output peak power of the high power short pulse LD light source 10, the peak intensity of short wave merits-and-demerits pulsed light will be set to 400-500mW.

[0012] t0 with which the timing of short wave merits-and-demerits pulsed light [such] of the maximum output of the peak of excitation pulsed light and short pulsed light corresponds like drawing 3 it is -- it sometimes obtains -- having -- t1 and t2 **** -- an output becomes small. Moreover, PO PP PS Since it is proportional to a product, the reinforcement of short wave merits-and-demerits pulsed light is controllable with the output of the LD excitation Q switch YLF laser light source 20. Here, the LD excitation Q switch YLF laser light source 20 is a source

of pulsed light, therefore since power density can be enlarged compared with CW light source, high power short wave merits-and-demerits pulsed light is obtained.

[0013] In addition, like drawing 4 (a), if it is made to make an excitation pulsed light beam and a short pulsed light beam cross in a nonlinear device 50, it will become unnecessary to establish the optical coupling means 4. What is necessary is just to take out short wave merits-and-demerits pulsed light using a slit 61 at this time. In addition, a dichroic mirror may be formed in the outgoing radiation end face of a nonlinear device 50 by multilayers etc. Since the component of a Cherenkov radiation mold may be used for a nonlinear device 50 and an outgoing radiation angle changes with wavelength like drawing 4 (b) in this case, a spectrum can be carried out to aperture or a slit 61.

[0014] Next, the concrete configuration of the timing synchronous means 3 is explained about some examples. The timing synchronous means 3 is constituted from drawing 5 by the timing synchronizing signal generating circuit 30 and the photodetector 31. here, excitation pulsed light and short pulsed light detect -- having -- this detection output -- a basis -- control by **** and the timing synchronizing signal generating circuit 30 is carried out. In drawing 5 (a), the leak light of the excitation light from a dichroic mirror 42 and short pulsed light which is an optical coupling means is used. In drawing 5 (b), incidence of the excitation light and short pulsed light which were taken out with the dichroic mirror 44 is carried out to the photodetector 31 from the light by which outgoing radiation was carried out from the nonlinear device 50.

[0015] Next, the above-mentioned photodetector 31 and the technique of synchronous control are explained. In drawing 6 , luminescence timing is controlled so that the peak of the sum of the power of excitation pulsed light and short pulsed light is detected and this peak value serves as max with the high-speed photodetector 46. In addition, with the configuration of drawing 5 (b), the high-speed photodetector 46 may also detect sum cycle light to the coincidence other than excitation pulsed light and short pulsed light, and luminescence timing may be controlled so that the peak serves as max.

[0016] At drawing 7 , it is high-speed photodetector 46P. Excitation pulsed light is detected and it is high-speed photodetector 46S. Short pulsed light was detected, and it has controlled so that time difference **t of this peak becomes zero. In this case, a dichroic mirror 44 is wavelength lambdaP. It reflects and is wavelength lambdaS. It penetrates. In addition, it cannot be overemphasized that the power of short wave merits-and-demerits pulsed light can be adjusted to arbitration by adjustment of this time difference **t.

[0017] Drawing 8 branches in a part of light (several %) from a nonlinear device 50, extracts sum cycle light with a filter 45 after this, and it carries out incidence to the high-speed photodetector 46, it detects it, and the case where timing control is performed is shown. If it does in this way, since the detection output of the high-speed photodetector 46 changes depending on time difference **t of the peak of short pulsed light and excitation pulsed light, it can perform control of output power. In this case, a low-speed thing may be used for a detector.

[0018] By performing the above timing control, even when the luminescence timing of the high power short pulse LD light source 10 or the LD excitation Q switch YLF laser light source 20 shifts with temperature, this can be amended to a request and stable actuation can be carried out. Moreover, if short pulsed light is doubled with the timing from which the output of arbitration reinforcement can also be obtained, for example, the output of excitation pulsed light becomes 50%, short wave merits-and-demerits pulsed light will be made to 50% of output. And an output can be changed continuously from the maximum power before zero power.

[0019] At this time, it becomes possible to make the start of short wave merits-and-demerits

pulsed light into Sharp, or to make timing of the peak of short pulsed light into falling Sharp based on the envelope of excitation pulsed light, by whether it doubles before the peak of excitation pulsed light, or it doubles with behind. In order to make adjustable power of short wave merits-and-demerits pulsed light, without the ability shifting the timing of excitation pulsed light and short pulsed light, the sharpness of the start and falling does not change in this case that what is necessary is just to change a spatial lap condition of two light. In addition, these may be used together, and if it does in this way, the intensity ratio at the time of adjustable [of short wave merits-and-demerits pulsed light / on the strength] can be enlarged.

[0020] Adjustment of the above reinforcement is more useful than the case where an ND filter etc. is used. Although pulse width will spread by distribution if an ND filter is used, it is because such disadvantageous profit is not produced according to this invention.

[0021] Furthermore, according to this invention, various conversion wavelength can be obtained compared with the case where SHG (higher harmonic) is used. That is, according to the SHG method, if LD light is 900nm and 450nm and LD light of output light are 830nm, output light is not set to 415nm, but according to this invention, various output wavelength is obtained by LD's remaining as it is, and changing the energy impregnation light source 2 into the thing of another wavelength, or performing the reverse by changing the combination of the light source. This is shown in <u>drawing 9</u> . However, it is necessary to make proper whenever [nonlinear device 50 or optical incident angle] in this case.

[0022]

[Effect of the Invention] As above, in this invention, excitation pulsed light and short pulsed light synchronize, incidence is carried out to a sum frequency generation means, and a sum cycle is generated by this. Here, if the timing of excitation pulsed light and short pulsed light is in agreement, the output of sum cycle light will serve as max, and an output is possible for adjustable by shifting timing. For this reason, the small source of short wave merits-and-demerits pulsed light which can obtain efficient on-the-strength adjustable short wave merits-and-demerits pulsed light can be offered.

TECHNICAL FIELD

[Industrial Application] Especially this invention relates to what uses sum cycle light for a detail about the source of short wave merits-and-demerits pulsed light.

PRIOR ART

[Description of the Prior Art] That for which wavelength uses a higher harmonic by 500nm or less as a generating technique of the short wave merits-and-demerits pulsed light of a picosecond region, and the thing using sum cycle light are known. In order to generate a higher harmonic, the approach using large-sized laser equipments, such as dye laser, the approach (APL.54 (17) PP.1625-1627) of generating within a high power laser cavity, or the method of leading semiconductor laser (LD) light to the waveguide which consists of a nonlinear medium is used.

Moreover, in order to generate sum cycle light, the approaches (Shingaku Giho, OQE 90-37, APL.54(9) PP.789-791, etc.) of setting a nonlinear device in a high power laser cavity, and mixing the output light of LD which carried out the high-speed modulation are used.

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TECHNICAL PROBLEM

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[0004] On the other hand, like JP,1-214082,A, a nonlinear device is set to the interior of the resonator of LD excitation solid state laser of CW oscillation, and there is the approach of mixing the output light of LD which carried out the high-speed modulation to use sum cycle light. However, according to this, LD excitation solid state laser cannot make CW oscillation, therefore power density high, but conversion efficiency stops to about 1%. Moreover, pulse width is not set to about 5ns, either. Furthermore, since LD output is not so large when a modulation is applied to LD for excitation of LD excitation solid state laser, a nonlinear effect is small, and since the output light of LD can be condensed only to one side of a nonlinear medium or a laser medium, power density does not go up in both media, and high power is not obtained. Then, this inventions are small and high power, and aim at offering the source of short wave merits-and-demerits pulsed light which can output short wave merits-and-demerits pulsed light.

MEANS

[Means for Solving the Problem] The 1st light source which the source of short wave merits-and-demerits pulsed light in connection with this invention makes generate excitation pulsed light, The 2nd light source which generates the short pulsed light of short pulse width from this excitation pulsed light, It has a synchronous means to synchronize the luminescence timing of the 1st and 2nd light sources, and a sum frequency generation means to generate sum cycle light by carrying out incidence of excitation pulsed light and the short pulsed light, and is characterized by making it output sum cycle light as short wave merits-and-demerits pulsed light.

OPERATION

[Function] According to the configuration of this invention, excitation pulsed light and short pulsed light synchronize, incidence is carried out to a sum frequency generation means, and sum cycle light is generated by this. Here, the wavelength of sum cycle light fully turns into short wavelength corresponding to the wavelength of excitation pulsed light and short pulsed light, and the pulse width becomes short enough according to the pulse width of short pulsed light. Moreover, if the timing of excitation pulsed light and short pulsed light is in agreement, the output of sum cycle light will serve as max, and an output is possible for adjustable by shifting timing.

EXAMPLE

[Example] Hereafter, the example of this invention is explained to a detail with reference to an accompanying drawing.
[0008] Drawing 1 is the block diagram showing the basic configuration of the source of short wave merits-and-demerits pulsed light concerning this invention. This equipment has two sources of pulsed light of the source 1 of short pulsed light, and the energy impregnation light source 2, and that luminescence timing is controlled to synchronize with the timing synchronous means 3. It is combined by the optical coupling means 4, and incidence of the short pulsed light from the source 1 of short pulsed light and the excitation pulsed light from the energy impregnation light source 2 is carried out to the sum frequency generation means 5.
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[0010] Drawing 2 shows the concrete example of the above-mentioned configuration. If it contrasts with drawing 1 , the source 1 of short pulsed light consists of the high power short pulse LD light sources 10, the energy impregnation light source 2 consists of LD excitation Q switch YLF laser light sources 20, and the timing synchronous means 3 consists of timing synchronizing signal generating circuits 30 so that clearly. Moreover, the optical coupling means

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[0013] In addition, like drawing 4 (a), if it is made to make an excitation pulsed light beam and a short pulsed light beam cross in a nonlinear device 50, it will become unnecessary to establish the optical coupling means 4. What is necessary is just to take out short wave merits-and-demerits pulsed light using a slit 61 at this time. In addition, a dichroic mirror may be formed in the outgoing radiation end face of a nonlinear device 50 by multilayers etc. Since the component of a Cherenkov radiation mold may be used for a nonlinear device 50 and an outgoing radiation angle changes with wavelength like drawing 4 (b) in this case, a spectrum can be carried out to aperture or a slit 61.

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lambdaP. It reflects and is wavelength lambdaS. It penetrates. In addition, it cannot be overemphasized that the power of short wave merits-and-demerits pulsed light can be adjusted to arbitration by adjustment of this time difference **t.

[0017] Drawing 8 branches in a part of light (several %) from a nonlinear device 50, extracts sum cycle light with a filter 45 after this, and it carries out incidence to the high-speed photodetector 46, it detects it, and the case where timing control is performed is shown. If it does in this way, since the detection output of the high-speed photodetector 46 changes depending on time difference **t of the peak of short pulsed light and excitation pulsed light, it can perform control of output power. In this case, a low-speed thing may be used for a detector.

[0018] By performing the above timing control, even when the luminescence timing of the high power short pulse LD light source 10 or the LD excitation Q switch YLF laser light source 20 shifts with temperature, this can be amended to a request and stable actuation can be carried out. Moreover, if short pulsed light is doubled with the timing from which the output of arbitration reinforcement can also be obtained, for example, the output of excitation pulsed light becomes 50%, short wave merits-and-demerits pulsed light will be made to 50% of output. And an output can be changed continuously from the maximum power before zero power.

[0019] At this time, it becomes possible to make the start of short wave merits-and-demerits pulsed light into Sharp, or to make timing of the peak of short pulsed light into falling Sharp based on the envelope of excitation pulsed light, by whether it doubles before the peak of excitation pulsed light, or it doubles with behind. In order to make adjustable power of short wave merits-and-demerits pulsed light, without the ability shifting the timing of excitation pulsed light and short pulsed light, the sharpness of the start and falling does not change in this case that what is necessary is just to change a spatial lap condition of two light. In addition, these may be used together, and if it does in this way, the intensity ratio at the time of adjustable [of short wave merits-and-demerits pulsed light / on the strength] can be enlarged.

[0020] Adjustment of the above reinforcement is more useful than the case where an ND filter etc. is used. Although pulse width will spread by distribution if an ND filter is used, it is because such disadvantageous profit is not produced according to this invention.

[0021] Furthermore, according to this invention, various conversion wavelength can be obtained compared with the case where SHG (higher harmonic) is used. That is, according to the SHG method, if LD light is 900nm and 450nm and LD light of output light are 830nm, output light is not set to 415nm, but according to this invention, various output wavelength is obtained by LD's remaining as it is, and changing the energy impregnation light source 2 into the thing of another wavelength, or performing the reverse by changing the combination of the light source. This is shown in drawing 9 . However, it is necessary to make proper whenever [nonlinear device 50 or optical incident angle] in this case.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the basic configuration of this invention.
[Drawing 2] It is drawing showing the basic configuration of an example.
[Drawing 3] It is drawing showing the generation principle of the short wave merits-and-demerits pulsed light of an example.

[Drawing 4] It is drawing in which the incidence of the excitation pulsed light to a nonlinear device 50 and short pulsed light is shown.

[Drawing 5] It is drawing having shown the configuration of the sum frequency generation means 5 concretely.

[Drawing 6] It is drawing showing an example of the configuration of the sum frequency generation means 5, and an operation.

[Drawing 7] It is drawing showing an example of the configuration of the sum frequency generation means 5, and an operation.

[Drawing 8] It is drawing showing an example of the configuration of the sum frequency generation means 5, and an operation.

[Drawing 9] It is the graph showing the combination of the source 1 of short pulsed light, and the energy impregnation light source 2.

[Description of Notations]

1 [-- A LD excitation Q switch YLF laser light source, 3 / -- A timing synchronous means, 30 / -- A timing synchronizing signal generating circuit, 31 / -- A high-speed photodetector, 4 / -- An optical coupling means, 42 / -- A dichroic mirror, 5 / -- A sum frequency generation means, 50 / -- A nonlinear device, 6 / -- An optical branching means, 60 / -- Spectroscope] -- The source of short pulsed light, 10 -- The high power short pulse LD light source, 2 -- The energy impregnation light source, 20